

S-5/PHSH/DSE-I/19

TDP (Honours) 5th Semester Exam., 2019

PHYSICS

(Honours)

PAPER - DSE - I

Full Marks : 80

Time : 3 Hours

*The figures in the margin indicate full marks.
Candidates are required to give their answers
in their own words as far as practicable.*

Section - A

1. Answer any *eight* of the following questions :

$2 \times 8 = 16$

- (i) Define packing fraction.
- (ii) Define mass defect.
- (iii) What is wave mechanical parity?
- (iv) Define angular momentum of the nucleus.
- (v) Write names of various models of the nucleus.

[Turn Over]

(2)

- (vi) Why stable nuclei have more neutrons than protons?
- (vii) What is the basic point of difference between the liquid drop model and shell model of the nucleus?
- (viii) Electrons as such do not exist in the nucleus. What then is the cause of β -decay?
- (ix) Write down the law of absorption of γ -rays in matter.
- (x) What is meant by particle accelerator? Can we accelerate neutrons by a cyclotron?
- (xi) On what factors does the range of α -particle depends?
- (xii) What is Cherenkov radiation?
- (xiii) What is meant by isospin?

Section - B

Answer any four questions : $16 \times 4 = 64$

2. (a) (i) Draw the binding fraction vs mass number curve. Write the significance of the curve.
- ✓ (ii) Derive an expression for nuclear magnetic moment.

(3)

- (iii) Derive an expression for the binding energy and mass of a nucleus in the ground state on the basis of semi-empirical mass formula of Weizsacker explaining different terms.
- (iv) Calculate the binding energy of the last neutron in the $^{209}_{82}\text{Pb}$ nucleus, using the semi-empirical mass formula.
- (v) What are magic nuclei?
 $(2+2)+3+5+3+1=16$

Or,

- (b) (i) Give experimental evidences in support of shell structure of nucleons in nuclei.
- (ii) State the main assumptions of the nuclear shell model and its limitations.
- (iii) Write about the concept of mean field.
- (iv) Write the characteristics of nuclear force.
- (v) Explain the salient features of the liquid drop model and give the various assumptions made. $3+(3+2)+2+2+4=16$

[Turn Over]

(4)

3. (a) (i) Derive the expression for the transmission probability in case of α -decay.

(ii) Explain neutrino hypothesis. Explain qualitatively how the hypothesis of a neutrino solves the apparent breakdown of conservation of momentum and energy in β -decay.

(iii) Write a short note on internal conversion.

(iv) Explain Geiger-Nuttall law relating to the ranges of α -particles in α -ray disintegrations and the half-value periods.

$$5+(2+3)+3+3=16$$

Or,

(b) (i) Derive Rutherford's formula and state how one can estimate the optimum radius of a nucleus from a study of α -ray scattering.

(ii) Describe different types of nuclear reaction. Write different types of conservation laws related to nuclear reactions.

(iii) What is meant by Q-value of a nuclear reaction? Compute the Q-values of the reaction : ${}^7_3\text{Li}(p, \alpha){}_2^4\text{He}$. Take the mass of

(5)

${}^1_1\text{H}$, ${}^7_3\text{Li}$ and ${}^4_2\text{He}$ as 1.00814, 7.01823 and 4.00387 respectively.

$$(5+3)+(2+2)+(2+2)=16$$

4. (a) (i) Derive the expression of Bethe-Bloch formula for energy loss due to ionization in heavy charged particles.

(ii) What do you mean by Cherenkov radiation?

(iii) Describe an ionisation chamber and give some of its important uses. $6+3+(4+3)=16$

Or,

(b) (i) What is Compton effect? Explain and derive an expression for Compton shift on the basis of quantum theory. Show that Compton shift in terms of wavelength is given by

$$\Delta\lambda = \frac{h}{m_0c}(1 - \cos\phi).$$

(ii) Why visible light cannot be used to demonstrate Compton effect?

(iii) An X-ray photon of initial frequency 3×10^{19} Hz collides with an electron and is scattered through 90° . Find its new frequency.

$$(2+7)+4+3=16$$

[Turn Over]

(6)

5. (a) (i) Describe the principle of working of a linear accelerator. Show that the total length of the linear accelerator is proportional to the wave length λ_1 of the radio frequency signal.
- (ii) Give the working of a electron synchrotron. Distinguish between cyclotron and synchrotron.
- (iii) Explain the difficulty of accelerating electrons in a cyclotron.
- (iv) What is the energy to which protons can be accelerated in a cyclotron with a dee diameter of 2m and a magnetic field of flux density 0.72 Wb/m^2 . Mass of proton = $1.673 \times 10^{-27} \text{ kg}$. $(3+3)+(3+2)+2+3=16$

Or,

- (b) (i) What do you mean by quarks? How many possible quarks are there? Write properties of quarks.
- (ii) What are the characteristics of strong, electromagnetic and weak interactions? Give the laws of conservation for these interactions.

(7)

- (iii) Is the reaction : $\pi^- + p^+ \rightarrow \pi^- + \pi^+ + \pi^-$ allowed? Explain the logic of your answer.
- (iv) What are strange particles? Explain clearly the meaning of strangeness.
- $(1+2+2)+(3+2)+(1+2)+(1\frac{1}{2}+1\frac{1}{2})=16$
-

S-5/PHSH/DSE-I/21

TDP (Honours) 5th Semester Exam., 2021

PHYSICS

(Honours)

PAPER : (DSE-I)

Full Marks : 80

Time : 3 Hours

The figures in the margin indicate full marks.

*Candidates are required to give their answers
in their own words as far as practicable.*

SECTION—A

1. Answer **any eight** questions of the following :

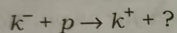
$2 \times 8 = 16$

- (a) Define nuclear magnetic moment.
- (b) What is the analogy between a nucleus and a liquid drop?
- (c) What are magic and semimagic numbers in nuclear physics?
- (d) How a cyclotron can be used to accelerate electron?

232
127
67

(2)

- (e) What do you mean by reaction rate of a nuclear reaction?
- (f) What do you understand by 'internal conversion'?
- (g) What is 'mirror nuclei'? Give examples.
- (h) What do you mean by fine structure of α -ray spectrum?
- (e) Identify the unknown particle in the following reaction.



- (f) Explain the phenomenon of inverse β -decay.
- (g) What is meant by range of α -particles?
- (f) Define antiparticles with examples.

SECTION—B

There are four questions from Question No. 2 to Question No.5. Answer either (a) or (b) from each question.

Answer the following questions :

$$16 \times 4 = 64$$

2. (a) (i) Explain the terms 'mass defect' and 'binding energy' of a nucleus.

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[Continued]

(3)

- (ii) Calculate the binding energy per nucleon for the deuteron. Given $m_n = 1.675 \times 10^{-27}$ kg, $m_p = 1.672 \times 10^{-27}$ kg, $m_D = 3.343 \times 10^{-27}$ kg, $c = 3 \times 10^8$ m/sec.
- (iii) Write a short note on "electric quadrupole moment of the nucleus".
- (iv) Explain the salient features of the liquid drop model. List out the various assumptions made while making the model.

$$(3+4)+3+(3+3)=16$$

(OR)

- (b) (i) Derive the expression for semi-empirical binding energy formula.
- (ii) Using the semi-empirical binding energy formula, calculate binding energy of $^{40}_{20}\text{Ca}$.
- (iii) Write a short note on the "size of the nucleus".
- (iv) Explain the salient features of the shell model of the nucleus. How does it explain the magic numbers in the ground state of the nucleus?

$$5+2+2+(3+4)=16$$

PHY-5/157

[Turn Over]

(4)

3. (a) (i) State the condition of α -decay and explain why in a α -decay of a radioactive nuclide, the K.E. of the emitted α -particles is a little less than the disintegration energy.
- (ii) "Electrons cannot exist as an integral part of the nucleus." Justify the statement.
- (iii) Discuss how neutrino hypothesis explain the β -decay and β -ray energy spectrum.
- (iv) Write the characteristics of γ -radiation.
(4+2)+3+5+2=16

(OR)

- (b) (i) Derive an expression for the Q-value of the reaction $X(a,b)Y$ in terms of K.E. of the incident and product particles and masses at the various particles and nuclei. Assuming the target nucleon to be initially at rest in the laboratory.
- (ii) Discuss the compound nucleus theory at nuclear reactions.
- (iii) The bombardment of lithium with protons gives rise to the reaction ${}^7_3\text{Li} + {}^1_1\text{H} \rightarrow {}^4_2\text{He} + {}^4_2\text{He} + \text{Energy}$. The atomic masses of lithium, hydrogen and helium are 7.016 amu, 1.008 amu and 4.004 amu respectively. Find the value of energy released in this reaction.

(5)

- (iv) Explain 'nuclear reaction cross-section'.
- (iv) Define attenuation and absorption coefficient of γ -ray when it passes through matter. (4+3)+3+2+2+2=16
4. (a) (i) Find the expression of momentum gained by the electron of the medium when a heavy particle is passing through the medium and interact with that electron.
- (ii) Explain pair production and annihilation of electron-positron pair.
- (iii) Explain the working principle of G-M counter with a neat diagram.
- (iv) An ionisation chamber is connected to an electrometer of capacitance 0.5 pF and voltage sensitivity of 4 divisions per volt. A beam of α -particle causes a deflection of 0.8 divisions. Calculate the number of ion pair required and the energy of the α -particle. Given that 1 ion pair requires energy of 35 eV and $e = 1.6 \times 10^{-19}$ coulomb. 5+3+5+3=16

(OR)

- (b) (i) What is Compton effect? Derive the expression for Compton Shift.
- (ii) Write a short note on 'Cherenkov radiation'.

(6)

(iii) With a clear diagram explain the working principle of 'photomultiplier tube'.

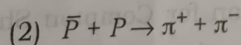
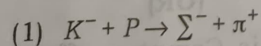
(iv) α -particles of energy 5 MeV pass through an ionisation chamber at the rate of 10 per second. Assuming all the energy is used in producing ion pairs, calculate the current produced. (35 eV is required for producing an ion pair and $e = 1.6 \times 10^{-19}$ coulomb)

$$(1+4)+3+5+3=16$$

5. (a) (i) Describe the working principle of a Van de Graaff generator. Write its advantages as well as disadvantages.

(ii) Explain 'strangeness' and 'hypercharge' in connection with elementary particles.

(iii) Choose the reaction allowed or not



$$(4+3)+(3+3)+3=16$$

[Continued]

(7)

OR

(b) (i) What are elementary particles? Mention different types of elementary particles and their families.

(ii) With a neat sketch, discuss the principle and working of a cyclotron.

(iii) What are baryon numbers and strangeness numbers?

(iv) Write a short note on Quark model.

$$(1+4)+5+3+3=16$$

S-5/PHSH/DSE-I/22

TDP (Honours) 5th Semester Exam., 2022

PHYSICS

(Honours)

FIRST PAPER : DSE - I

Full Marks : 80

Time : 3 Hours

Answer from **both** the Sections as directed.

The figures in the margin indicate full marks.

Candidates are required to give their answers
in their own words as far as practicable.

SECTION—A

1. Answer any **eight** of the following questions :

$2 \times 8 = 16$

- (a) Define angular momentum of the nucleus.
- (b) Show that the density of nucleus is independent of mass number.
- (c) What is wave mechanical parity?
- (d) What is the significance of Q-value?

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[Turn Over]

(2)

- (e) Write Geiger-Nuttall law.
- (f) Explain the term nuclear reaction cross-section.
- (g) What is tunnel effect?
- (h) Explain Bremsstrahlung.
- (i) What is radiation length?
- (j) What are Hadrons?

SECTION—B

There are *four* questions from Question No. 2 to Question No. 5. Answer either (a) **or** (b) from each question given below :

$$16 \times 4 = 64$$

2. (a) (i) Explain about Nuclear stability w.r.t. neutron-proton ratio and also explain why stable nuclei have more neutrons than protons.
- (ii) What is binding energy per nucleon? Discuss graphically the variation of average binding energy per nucleon with mass number and stability of the nucleus.
- (iii) Calculate the packing fraction and average binding energy per nucleon for $^{80}_{16}\text{Br}$ of nuclear mass 79.916318 u; given $m_p = 1.007825 \text{ u}$, $m_n = 1.008665 \text{ u}$.

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[Continued]

(3)

- (iv) State the basic assumptions of liquid drop model and show how it can explain the nuclear fission.

$$(2+2) + (1+4) + 3 + 4 = 16$$

(OR)

- (b) (i) Write the basic differences between liquid drop model and shell model of the nucleus.

- (ii) What is the evidence for the shell structure of the nuclei?

- (iii) Stating the main assumptions, explain the nuclear shell model and its limitations.

- (iv) Explain that nuclear forces are charge independent and nuclear forces are exchange forces.

$$2 + 3 + (2 + 3 + 2) + (2 + 2) = 16$$

3. (a) (i) Explain why high energy of α -particles favours their emission.

- (ii) What is meant by range of an α -particle? On what factors does it depend? Explain straggling effect.

- (iii) Explain neutrino hypothesis. Explain qualitatively how the hypothesis of a neutrino solves the apparent breakdown of conservation of momentum and energy in β -decay.

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[Turn Over]

(4)

- (iv) What do you mean by internal conversion? How is it different from photo-electric effect?

$$2+(1+2+2)+(2+4)+(1+2)=16$$

(OR)

- (b) (i) Describe different types of nuclear reaction.

- (ii) Write different types of conservation laws related to nuclear reactions.

- (iii) Calculate the threshold energy required to initiate the reaction

$$P^{31}(n, p)Si^{31}; \text{ Given } m_p = 1.00814 \text{ u}$$

$$m_n = 1.00898 \text{ u}$$

$$M_P = 30.98356 \text{ u}$$

$$M_{Si} = 30.98515 \text{ unit.}$$

- (iv) Discuss Gamow's theory of emission of α -particle from a radioactive substance.

$$4+4+3+5=16$$

4. (a) (i) Derive the expression of Bethe-Bloch formula for energy loss due to ionization by a moving heavy charged particle in the surrounding medium.

- (ii) Explain why the energy loss of electrons is much more complicated phenomenon compared to the energy loss by ionisation of heavy ions.

(5)

- (iii) Discuss the working of scintillation Detector.

- (iv) Write the uses of scintillation detector.

$$6+3+5+2=16$$

(OR)

- (b) (i) Describe the construction and working theory of an ionisation chamber.

- (ii) What are the advantages and disadvantages of using GM counter over Ionisation chamber.

- (iii) A G. M counter produces 4.5×10^8 ions per discharge. If it responds to an incident radiation 10 times per sec, what is the average ion current through the counter?

- (iv) Describe the main process of interaction of γ -radiation with matter by which radiation loses energy on passage through matter.

$$6+4+2+4=16$$

5. (a) (i) Explain, what is meant by resonance condition in a cyclotron. Derive an expression for the maximum energy produced in this machine. What happens when the energy becomes relativistically high?

- (ii) Write a short note on Hyperons.

[Turn Over]

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[Continued]

(6)

- (iii) Check if the following reactions are allowed or forbidden :

$$\pi^- + p \rightarrow \Lambda^0 + \pi^0$$

$$\text{and } p + \bar{p} \rightarrow 2\pi^+ + 2\pi^- + 2\pi^0$$

$$(2+3+2)+3+(3+3)=16$$

(OR)

- (b) (i) Describe the construction and working of an electron synchrotron.

- (ii) What are strange particles? How are the strangeness quantum number, baryon number and the third component of isotopic spin related to the elementary particles?

- (iii) What do you mean by 'quarks'? How many possible quarks are there? Give the charge and quantum number associated with each quark. How do the quarks combine to form proton and π^+ meson?

$$5+(1+3)+(1+1+3+2)=16$$

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S-5/PHSH/DSE-I/23

TDP (Honours) 5th Semester Exam., 2023

PHYSICS

(Honours)

FIRST PAPER : DSE - I

Full Marks : 80

Time : 3 Hours

Answer from **both** the Sections as directed.

The figures in the margin indicate full marks.

Candidates are required to give their answers
in their own words as far as practicable.

SECTION—A

1. Answer any **eight** of the following questions :

2×8=16

(a) Write names of various models of the nucleus.

(b) Write the similarities between a nucleus and a liquid drop.

(c) What are magic and semi-magic numbers in nuclear physics?

2, 8, 20, 50, 82, 126

14, 28, 40

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[Turn Over]

(2)

- (d) What do you mean by reaction rate of nuclear reaction?
- (e) How can a cyclotron be used to accelerate electrons?
- (f) What is Q-value of nuclear reaction?
- (g) What do you mean by internal conversion?
- (h) Define antiparticles with examples.
- (i) What is Cherenkov radiation?
- (j) What is meant by isospin?

SECTION—B

There are four questions from Question No. 2 to Question No. 5. Answer either (a) or (b) from each question given below : $16 \times 4 = 64$

2. (a) (i) Define packing fraction. Show graphically the variation of packing fraction with mass number and write its significance.

(3)

- (ii) Derive an expression for nuclear magnetic moment.
- (iii) Calculate the binding energy per nucleon for the deuteron.

Given, $m_n = 1.675 \times 10^{-27} \text{ kg}$

$m_p = 1.672 \times 10^{-27} \text{ kg}$

$m_D = 3.343 \times 10^{-27} \text{ kg}$

$c = 3 \times 10^8 \text{ m/sec}$

- (iv) Write about the size and density of nucleus. $(1+2+2)+4+3+4=16$

(OR)

- (b) (i) Derive an expression for the binding energy on the basis of semi-empirical formula of Weizsacker.
- (ii) How does the shell model of the nucleus explain the magic numbers in the ground state of the nucleus?
- (iii) Discuss the failure and limitations of shell model.
- (iv) Write the characteristic of nuclear force. $5+5+3+3=16$

(4)

3. (a) (i) Derive the expression for the transmission probability in case of α -decay.
- (ii) Discuss how neutrino hypothesis explains the β -decay and β -ray energy spectrum.
- (iii) Explain Geiger-Nuttall law relating to the ranges of α -particles.
- (iv) How is internal conversion different from photoelectric effect? $5+5+3+3=16$

(OR)

- (b) (i) Discuss the compound nucleus theory of nuclear reactions.
- (ii) What is nuclear reaction cross-section? Give the physical interpretation of nuclear reaction cross-section.
- (iii) Calculate Q-value of the reaction : ${}^7_3\text{Li}(p,\alpha){}^4_2\text{He}$; take the mass of ${}^1_1\text{H}$, ${}^7_3\text{Li}$ and ${}^4_2\text{He}$ as 1.00814, 7.01823 and 4.00387 amu respectively, what type of reaction is it?
- (iv) Name different types of conservation laws related to nuclear reactions.
 $5+(1+3)+(3+1)+3=16$

4. (a) (i) Explain the working principle of G-M counter with a neat diagram.

PHSH-5/1503

[Continued]

(5)

- (ii) Derive an expression for momentum gained by the electron of the medium when a heavy particle is passing through the medium and interact with that electron.
- (iii) An ionization chamber is connected to an electrometer of capacitance 0.5 pF and voltage sensitivity of 4 divisions per volt. A beam of α -particle causes a deflection of 0.8 divisions. Calculate the number of ion pair required and the energy of the α -particle. Given that one ion pair requires energy of 35 eV and $e = 1.6 \times 10^{-14}$ coulomb.
- (iv) Write the advantages and disadvantages of using G-M counter over ionisation chamber. $5+5+3+3=16$

(OR)

- (b) (i) Explain the working theory of Photomultiplier Tube (PMT) with diagram.
- (ii) Write short notes on pair production and annihilation of electron-positron pair.
- (iii) Discuss about the neutron interaction with matter.

PHSH-5/1503

[Turn Over]

(6)

- (iv) Define attenuation and absorption coefficients of gamma rays in case of interaction with matter.

$$5+(3+3)+3+2=16$$

5. (a) (i) Describe the working principle of a linear accelerator. Show that the total length of the linear accelerator is proportional to the wavelength λ_1 of the radio frequency signal.

- (ii) Write the differences between cyclotron and synchrotron.

- (iii) Write a short note on Quark model.

- (iv) What are strange particles? Explain the meaning of strangeness. $5+3+4+4=16$

(OR)

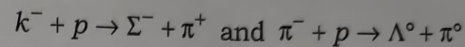
- (b) (i) Describe the working theory of a van de Graaff generator. Write its advantages as well as disadvantages.

- (ii) What are elementary particles? Mention different types of elementary particles and their families.

- (iii) What are Hadrons and Hyperons?

(7)

- (iv) Check whether the following reactions are allowed or forbidden :



$$5+4+3+4=16$$

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